Towards Skeleton based Reconstruction: From Projective Skeletonization to Canal Surface Estimation

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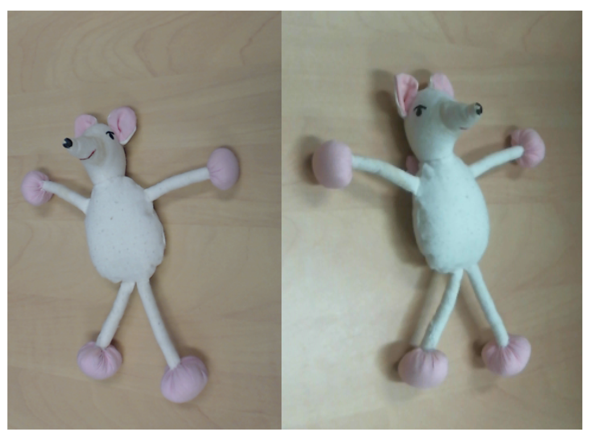
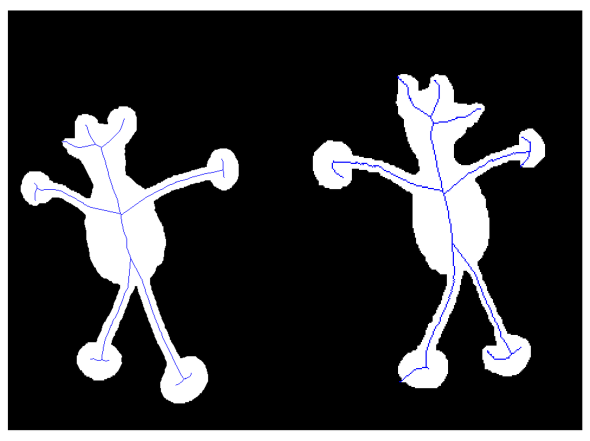
Pipeline

Images acquisition



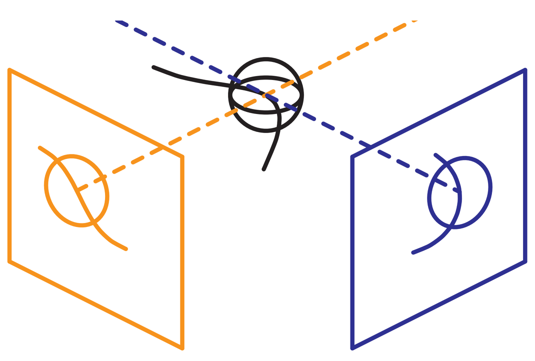
- Two different viewpoints
- Camera intrinsics known
- Camera pose known

Contribution I Projective skeletonization



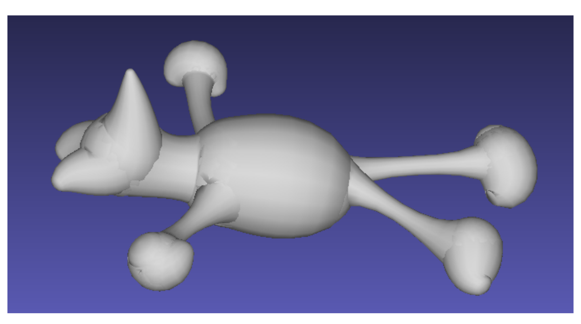
- What is the projection of a 3D skeleton?
- How to compute it from the shape projection?
- 2 cases: orthographic and perspective

Contribution II 3D skeleton triangulation



- Input: 2 parameterized projective skeletons
- How to pair both parameterizations and triangulate the 3D skeleton?

3D model reconstruction



Mesh computed from canal surface formulas

Problem

How to reconstruct a 3D object with its topology from two calibrated images?

Approach

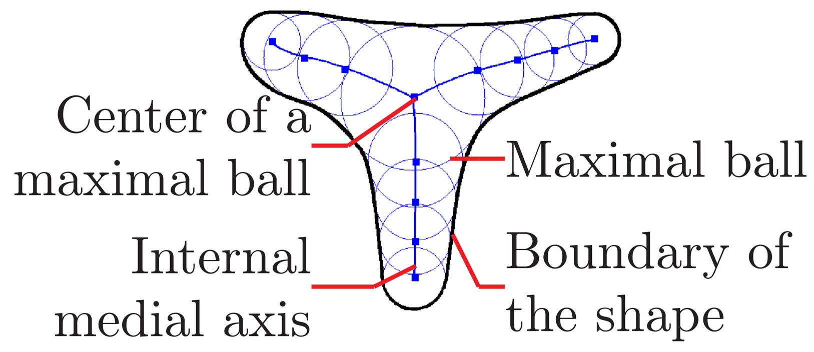
- Reconstruction of the **skeleton** of the object

Advantages

- No need of interest points
- Only two images
- Recovers
  * Object topology
  * Mesh

Definitions

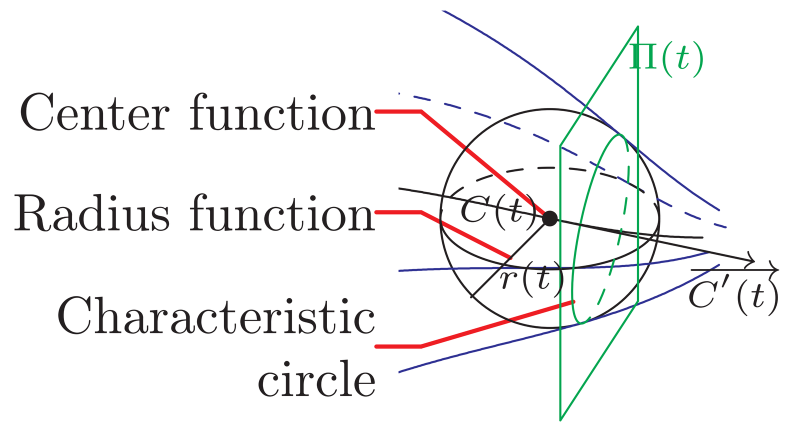
Skeleton [1]



Internal medial axis + Associated radii

Maximal ball: at least two tangency points

Canal Surface [2]

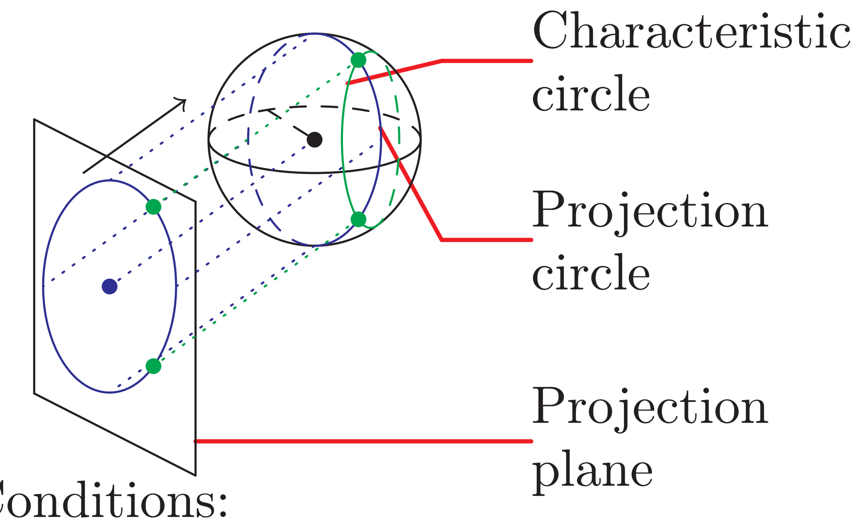


- Continuous center/radius functions: $C(t)$, $r(t)$
- Characteristic circle: tangency between the sphere and the surface
- $\Pi(t) := P \in \mathbb{R}^3,\ \overrightarrow{C(t)P} \cdot \overrightarrow{C'(t)} = r(t)r'(t)$

I Orthographic case

Sphere projection: circle

Maximal sphere projection: maximal circle?



Conditions:

- no self-occlusion
- 2 points on characteristic and projection circles

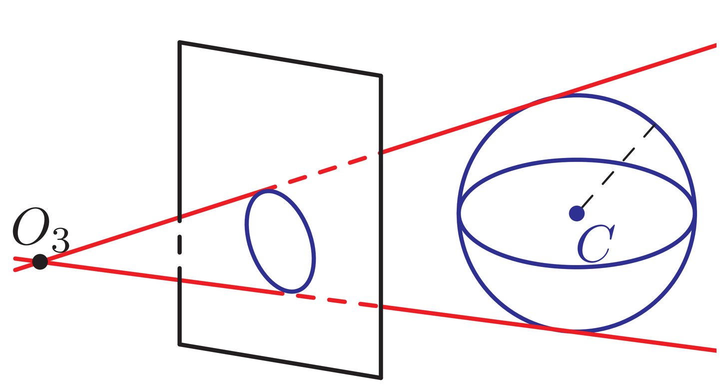
Orthographic skeleton = Skeleton of the projection

Solution: Classical skeletonization (*e.g.* Voronoï method [3])

I Perspective case

Perspective projection of a 3D skeleton: Ellipse-composed skeleton

Classical skeletonization does not work here !

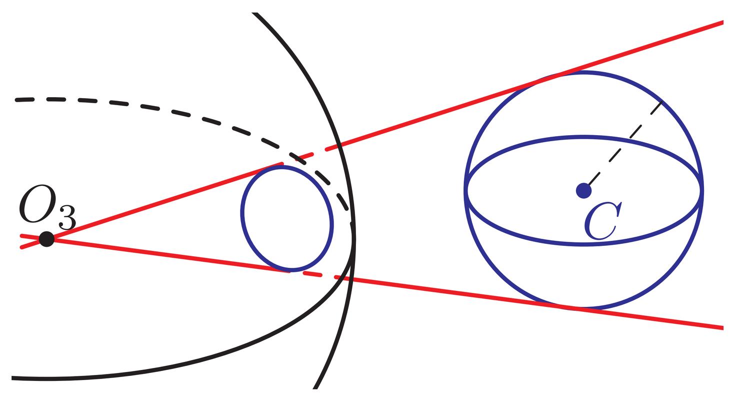


For one image and constant radius: Caglioti *et al.* in [4].

How to compute the projection of a canal surface with non-constant radius?

Sphere projection on the unit sphere: Circle

Idea: Skeletonization on the unit sphere



Algorithm

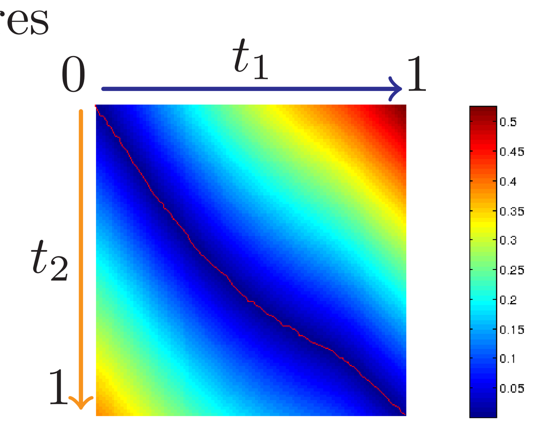
Perspective skeletonization

- Projection of the boundary on the unit sphere
- Delaunay tetrahedralization of the point set

II Skeleton triangulation

Curve pairing

Matching of the points on the curves, to triangulate the position of the spheres

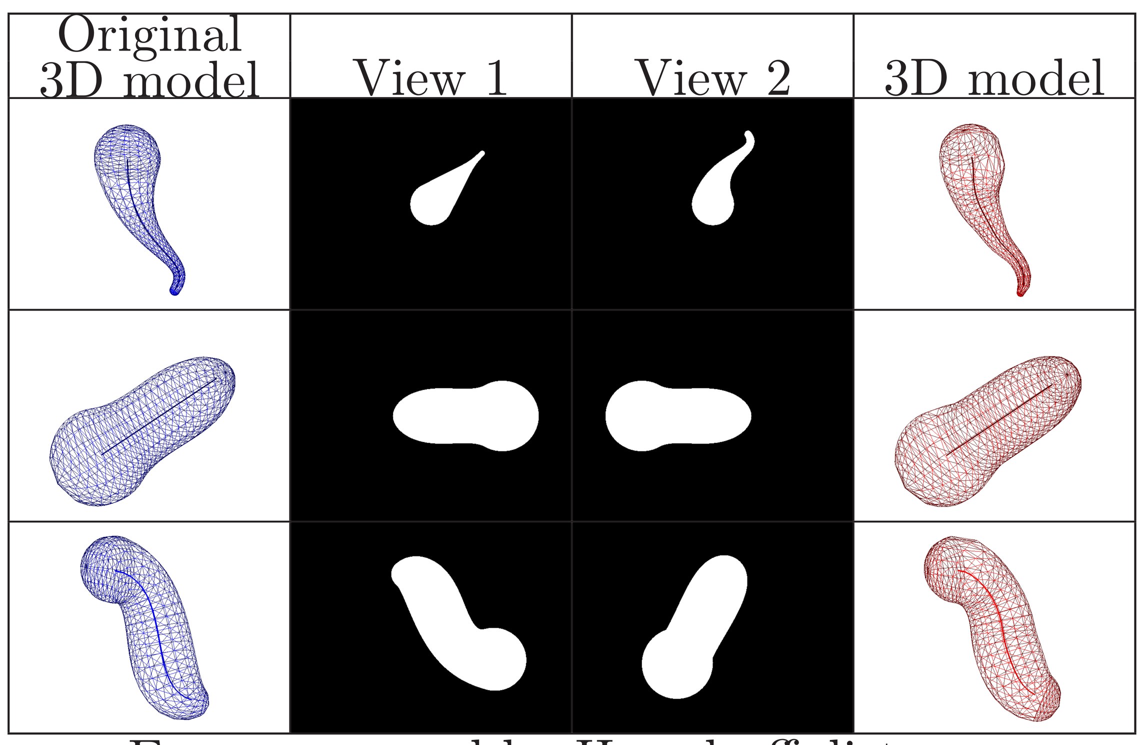


Distance map: Represents distance between parameterisations of blue skeleton and orange skeleton

Searching for the minimal path for up left corner to down right corner with Dijkstra algorithm

Implicit hypothesis: curve skeleton

Evaluation



Error measured by Hausdorff distance, normalized by the bounding box diagonal

Shape 1: 2.13%, Shape 2: 2.21%, Shape 3: 1.04%

Results

One of the two images

Result

Reconstruction of different objects using the proposed method. The different branches are associated semi-automatically.

Perspectives

- Automatic reconstruction of composed skeletons
- Detection and taking into account self-occlusions
- Use more than two images
- Reconstruction of surface skeletons

References

[1] H. Blum, *A Transformation for Extracting New Descriptors of Shape*, Models for the Perception of Speech and Visual Form, 1967

[2] M. Peternell and H. Pottmann, *omputing Rational Parametrizations of Canal Surfaces*, Journal of Symbolic Computation, 1997

[3] R. Ogniewicz and M. Ilg, *Voronoi skeletons : Theory and applications*, CVPR, 1992

[4] V. Caglioti and A. Giusti, *Reconstruction of Canal Surfaces from Single Images Under Exact Perspective*, ECCV 2006